Estimating VOC Emissions From Agricultural Fumigants

David A. Sullivan
Certified Consulting Meteorologist
Sullivan Environmental Consulting, Inc.

Objectives of Emissions Assessments

- Research of alternative mitigation strategies
- Input to buffer zone modeling
- Computation of percent product loss

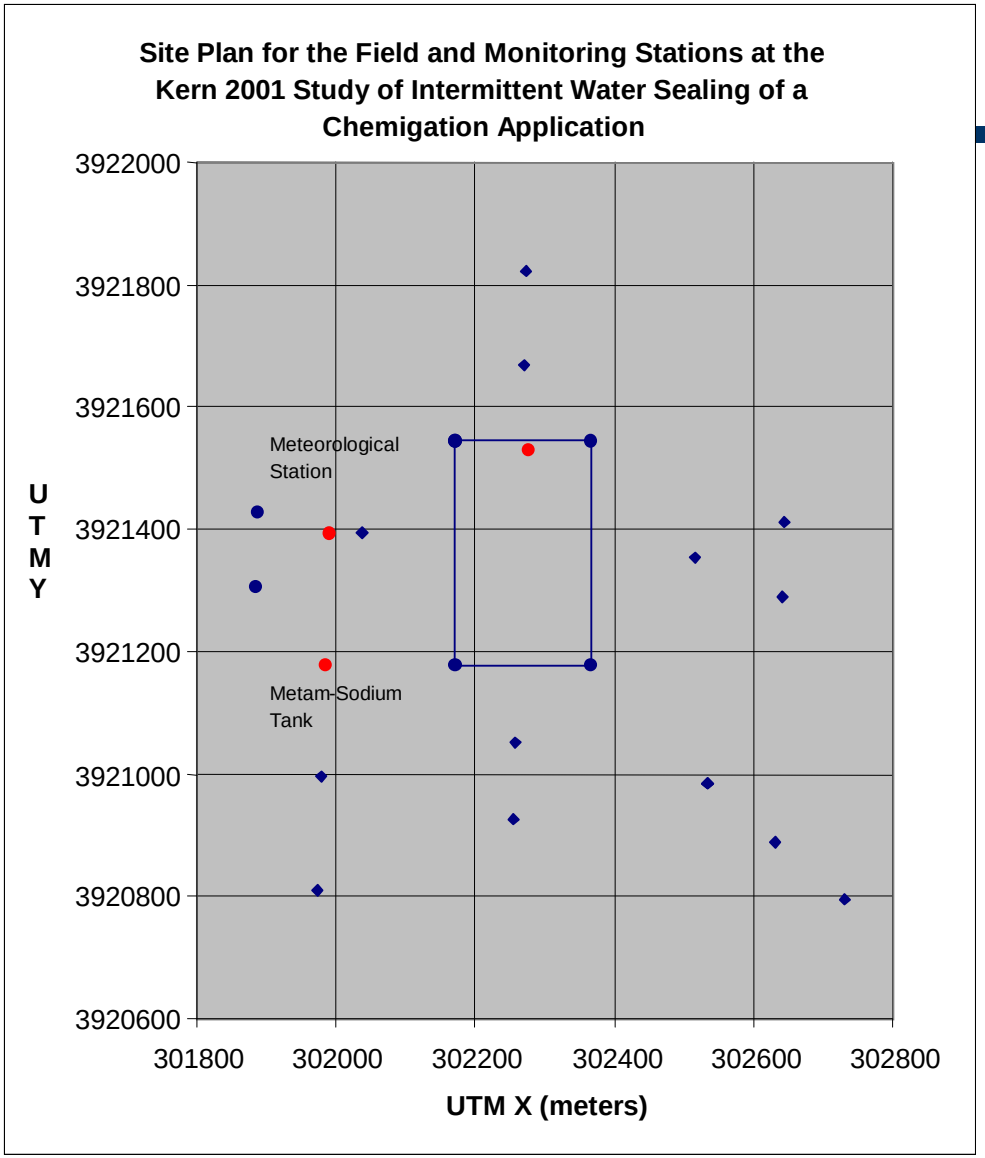
Primary Methods

- Off-field ambient (back calculation) method
- On-field profile method
- On-field flux chamber method

Design Criteria for Ambient Method

- 8-20 off-field monitors (minimum of 12 preferred)
- 50-300 m from field for field sizes 1-20 acres
- Square fields ideal
- 360 degree coverage needed

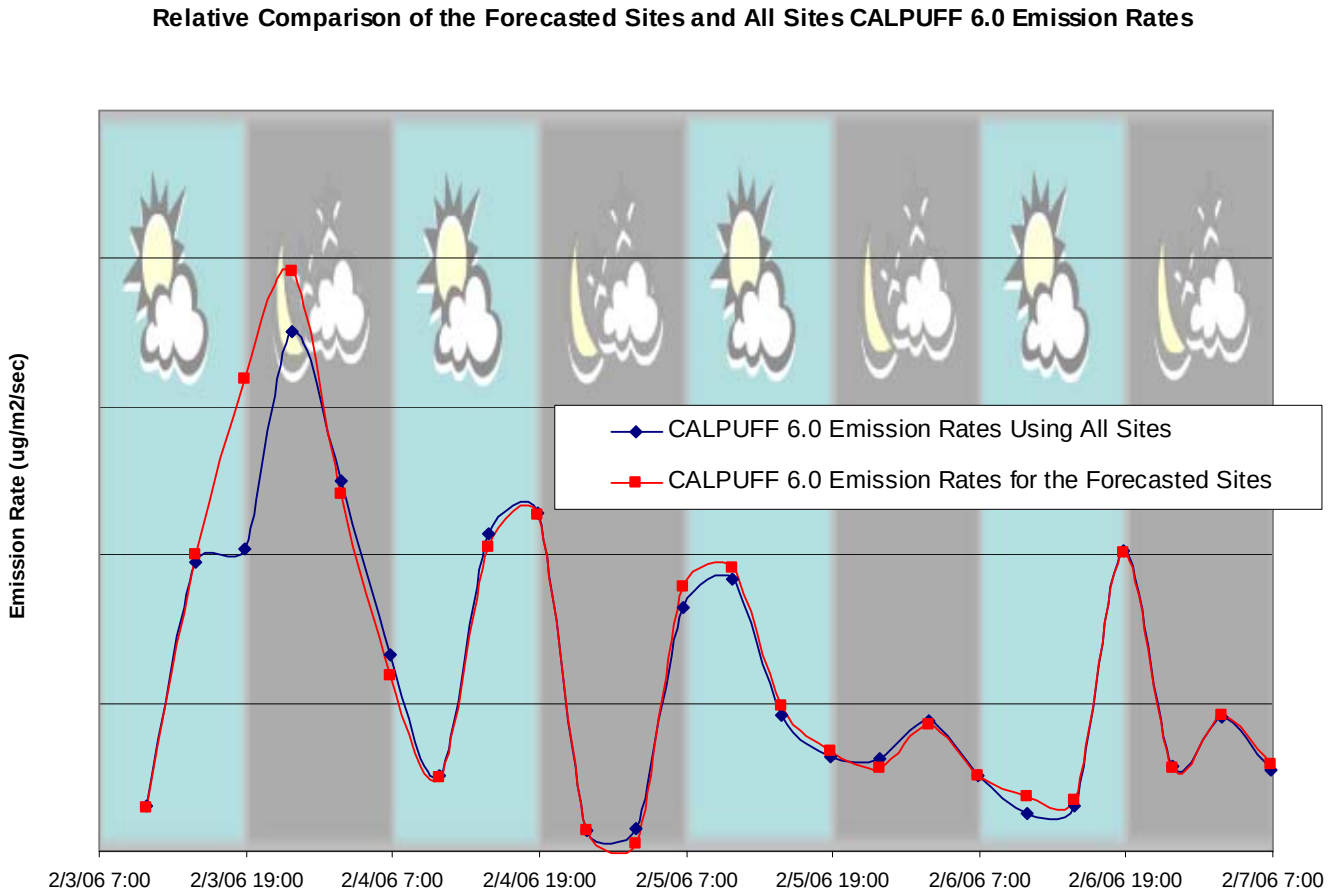
Typical Ambient Network



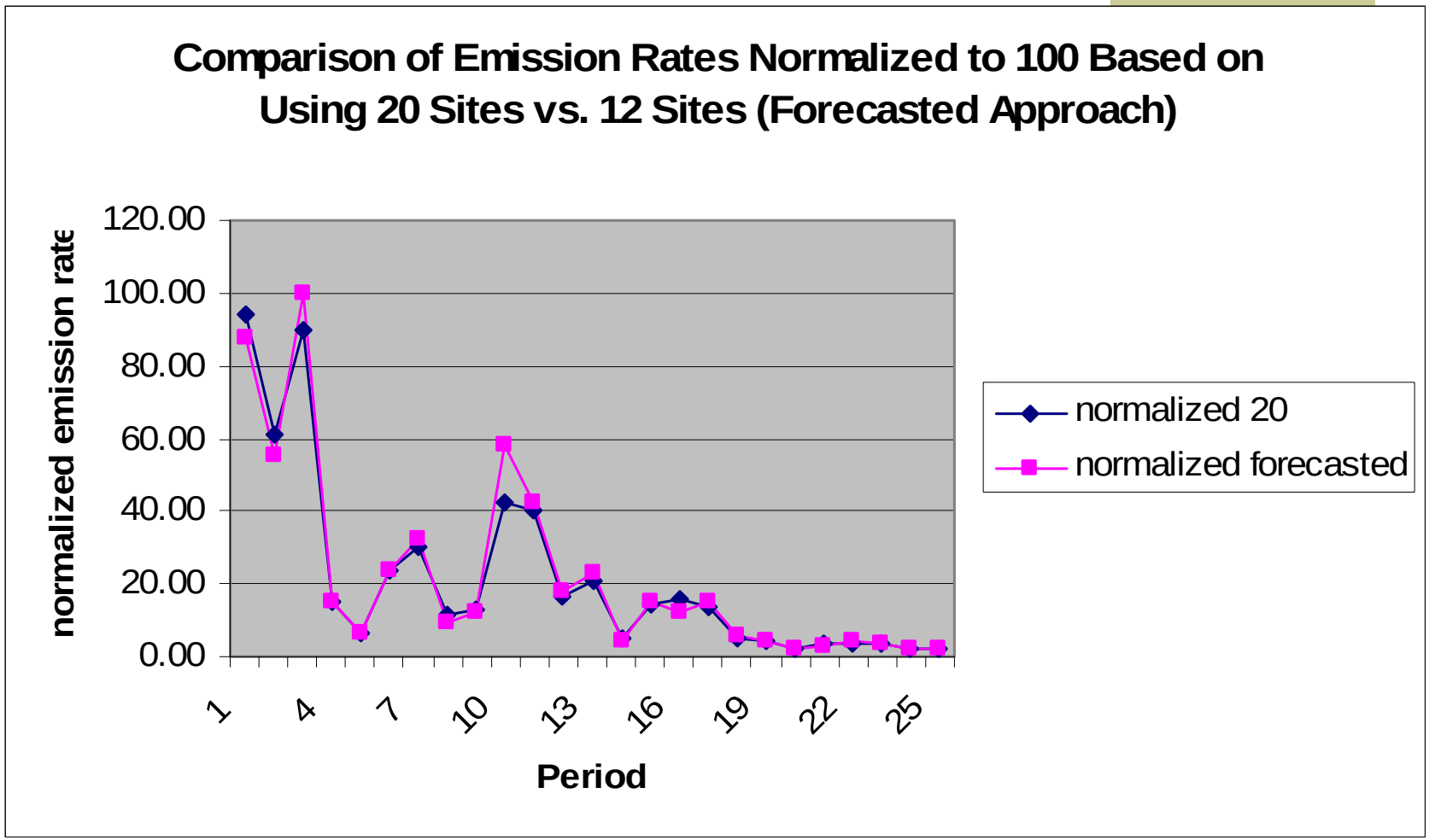
Example 3D Sonic Anemometer - - Standard Height Set to 20 ft Agl

Example Monitoring Site for Ambient Method

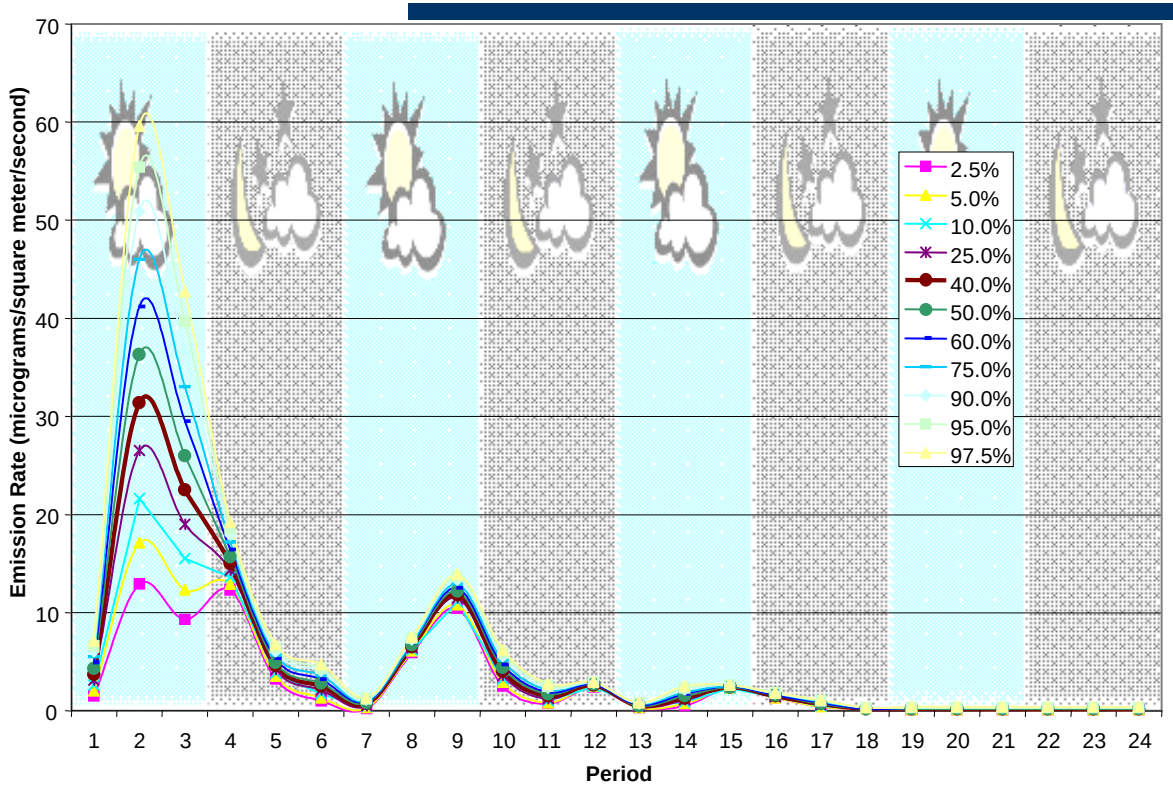
Variation on Ambient Method: Forecast Approach (8 core; 12 supplemental)



September 2005 Field Study Forecasted (12) vs. 20 Sites (early start chemigation 2005)



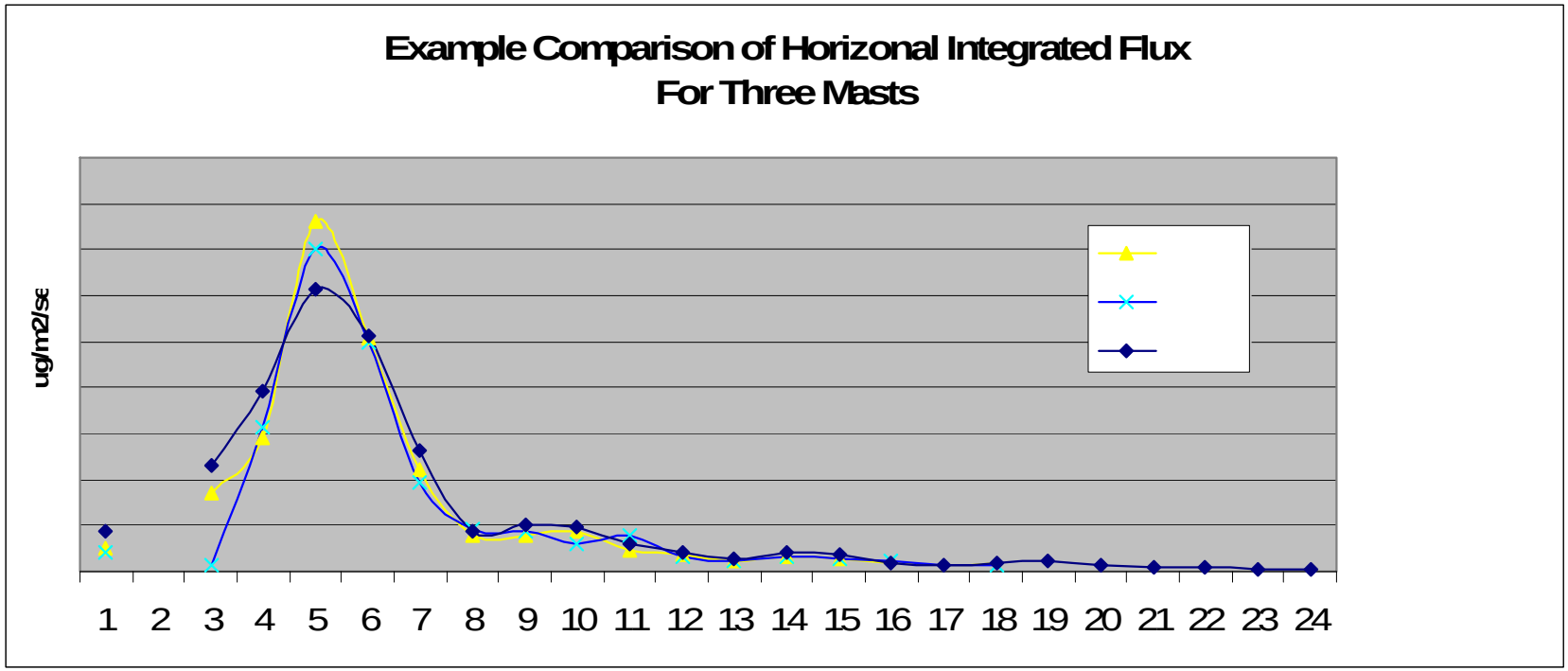
Example: Example Emission Distribution Based o Ambient Method



(can do the same with Multiple on-field masts)

Buffer zone management goals: (1) minimize peaks, and (2) shift peaks out of nighttime periods.

Example of Multiple Masts Data to Support Emission Distributions



On-Field Profile Method

- Profile height is function of field size
- < 1 acre: 0.5', 1.5', and 3'
- 20 acres: 0.5', 2.5', and 6'
- 100 m + separation allows for up to four sub-plots to be done concurrently for mitigation research
- Sonic anemometers used to capture low wind speed events
- Interpolated profiles used for wind speed and concentration

Pros & Cons of On-Field Flux Methods

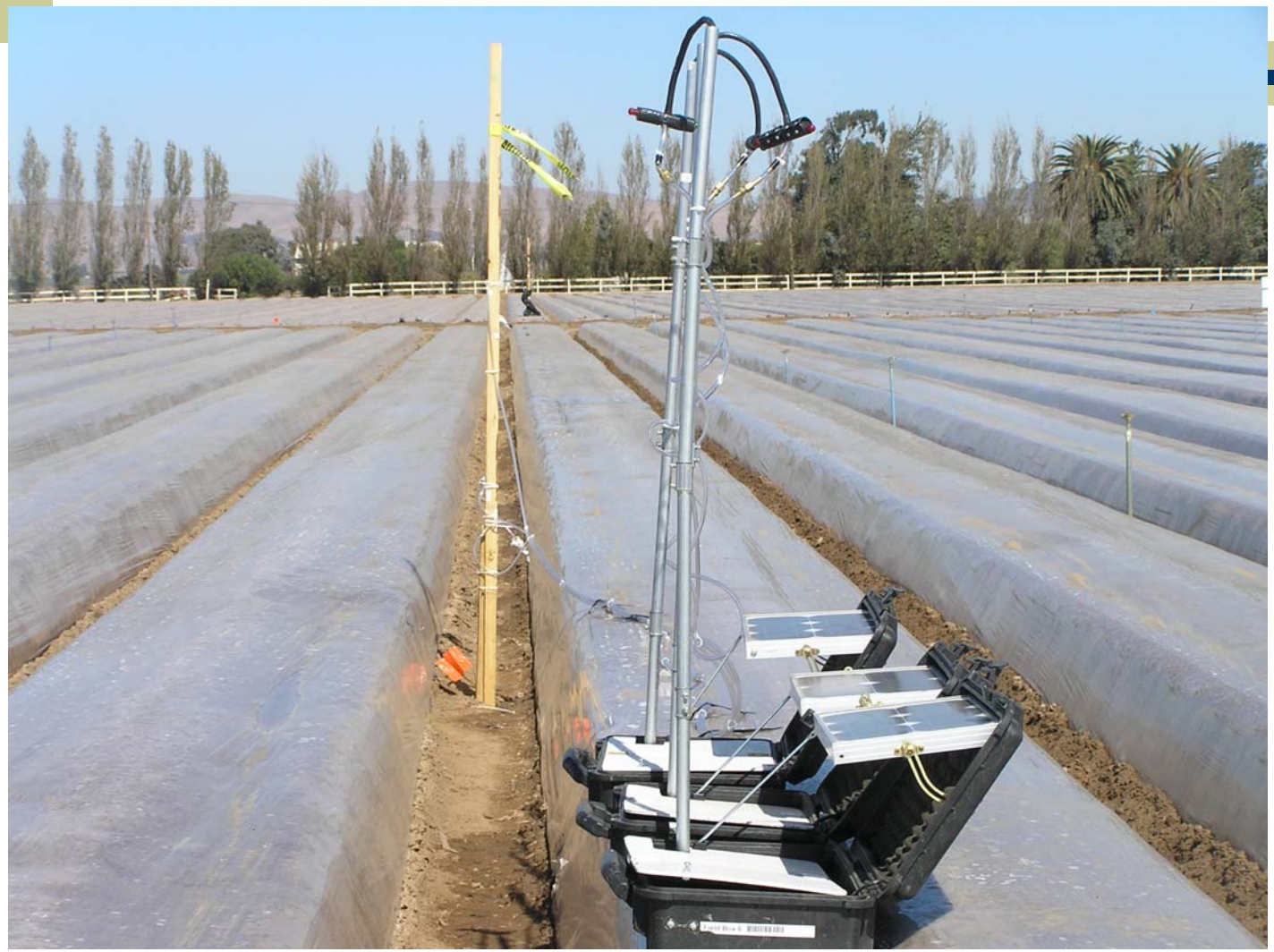
Method	Advantages	Disadvantages
Gradient Method	No need to capture full extent of plume	Dependent on turbulence theory - - weak during stable conditions
Integrated Horizontal Flux Method	More direct method	Dependent on extrapolating conc. & ws

On-Field Flux

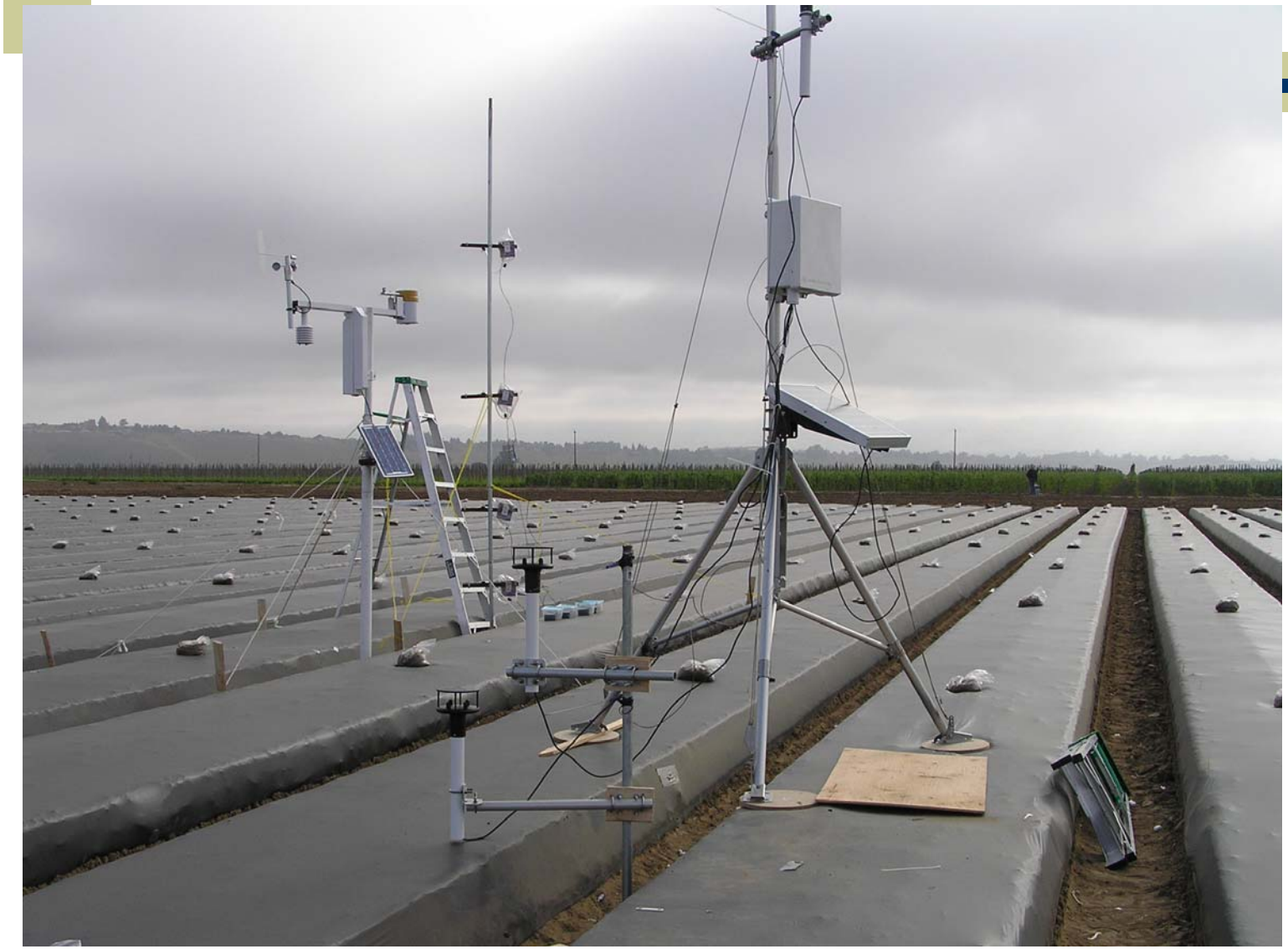
(Power Supply, Mast Profile, Meteorological Monitoring)

On-Field Flux (Cont)

(Power Supply, Mast Profile, Meteorological Monitoring)

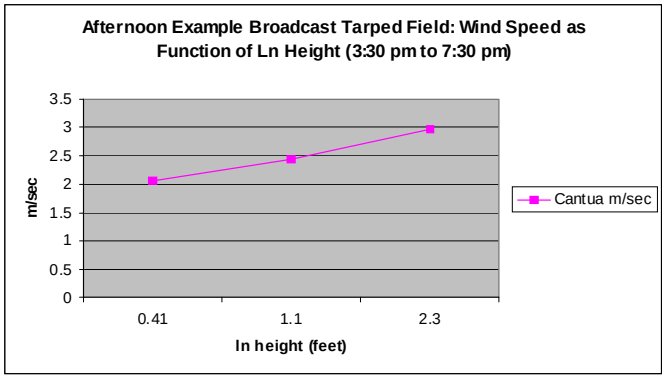


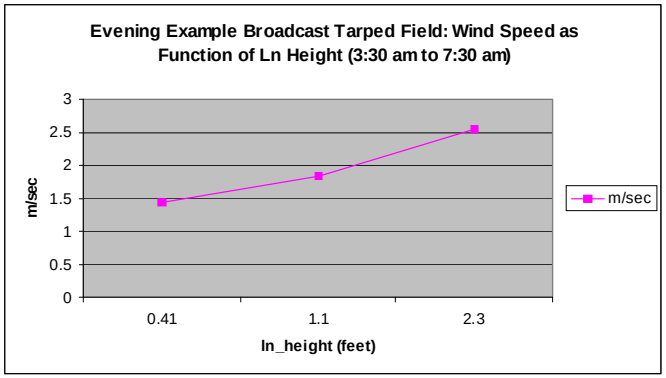
On-Field Flux Example (bedded, polyethylene tarp)



Fitted Representation of Profiles

Scaling Wind Speed Along Profile

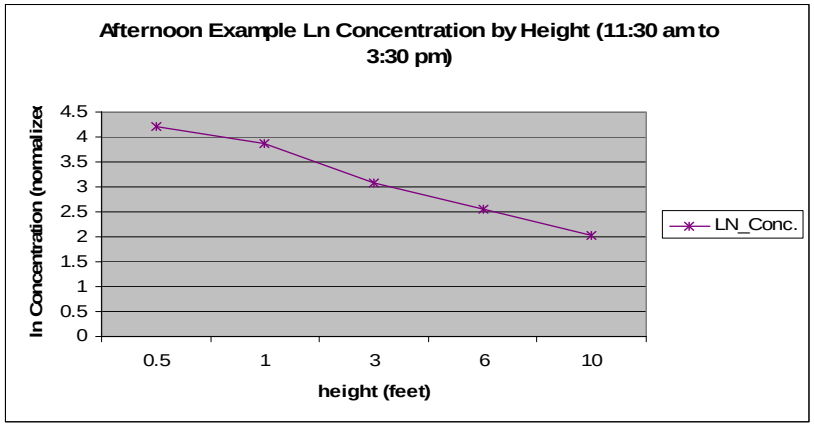


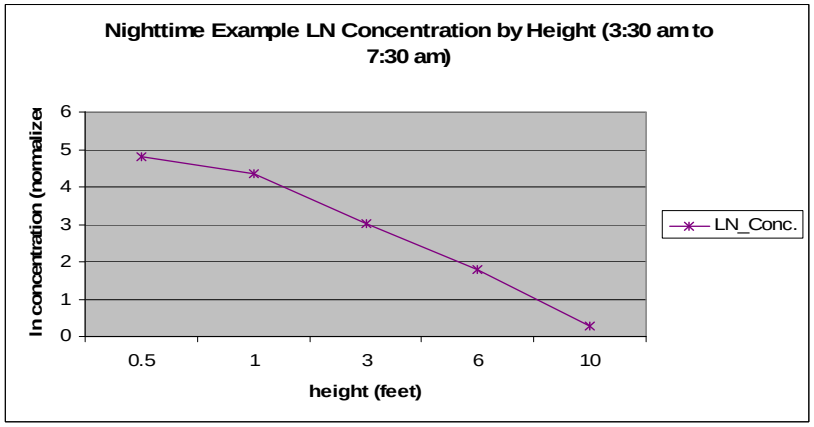


Also can be extrapolated by turbulence scaling theory.

Scaling Concentration Along Profile

(normalized for example)





Note: Slight Kink in Profile < 1 foot

Method Calculation: Ambient Method

- Calculated based on regressing normalized modeling and measured concentrations - - -one time step (e.g. 4-6 hours) at a time
- Normalized modeling based on CALPUFF 6 preferred (especially for low wind speed, nocturnal conditions
- Standard error of fit used to allow Monte Carlo sampling of emissions distribution for each sampling period

Method Calculation: Profile Method

$$Q = \frac{1}{x}\int_{z_o}^{z_p}\left(\overline{u}\,\overline{C}_{dw} - \overline{u}\,\overline{C}_{uw}\right)dz$$

Where:

Q (emission flux) = $\mu g/m^2/sec$

C_{dw} = Average downwind concentration ($\mu g/m^3$)

C_{uw} = Average upwind concentration ($\mu g/m^3$), assumed to be 0

x = fetch across treated field (m)

u = mean wind speed at the top of the layer (Sharon, 2005)

Method Calculation: Profile Method (Cont.)

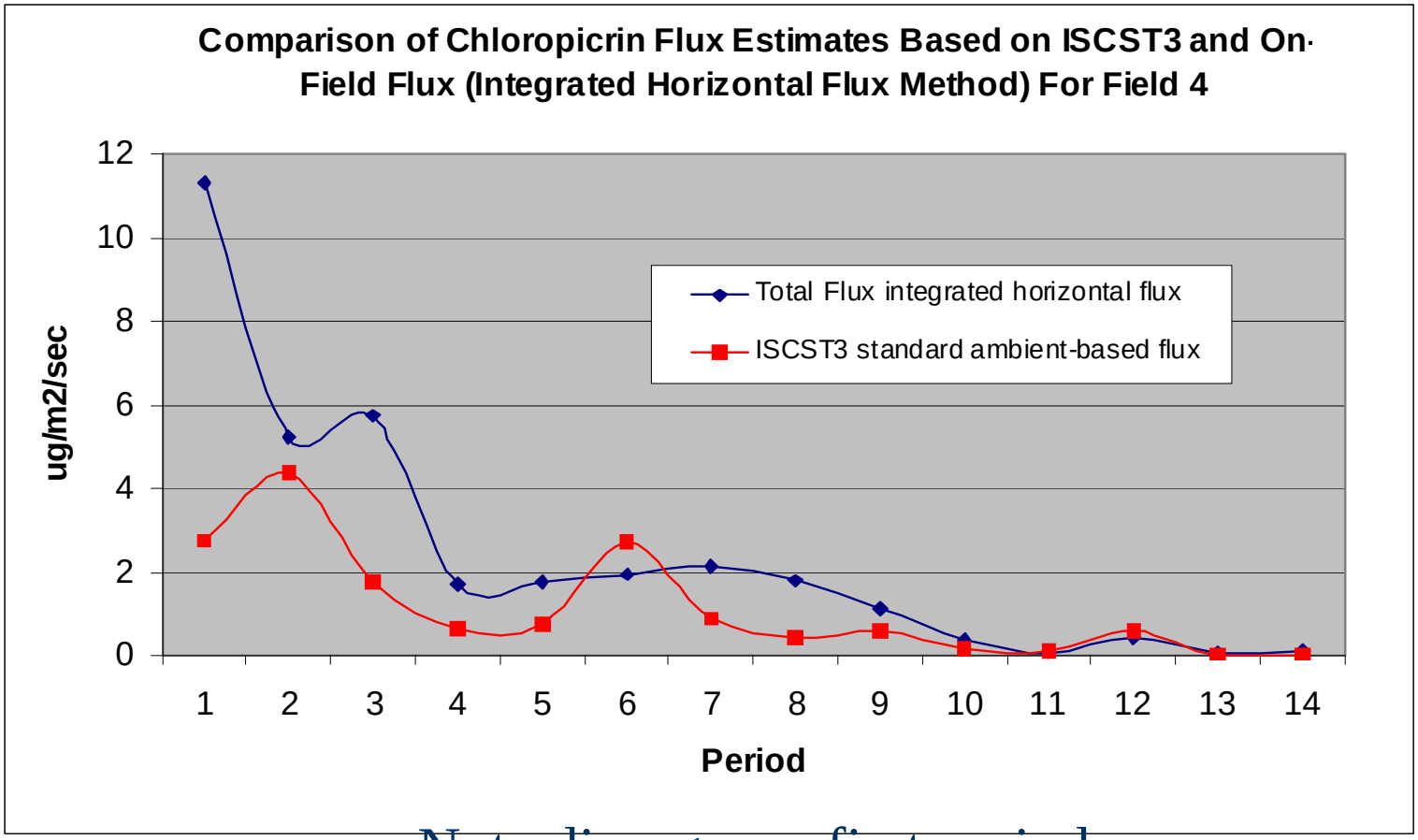
Regression fitted profiles for ln of concentration by height, and wind speed as a function of the ln of height

The layers were established as follows:

Layer (ft)	Wind Speed Height (ft)	Concentration (ft)
0-1.25	1.25	0.5
1.26 – 2	2	1.5
2.1-4.5	4.5	3
4.6-8	8	6
8.1-12	12	10

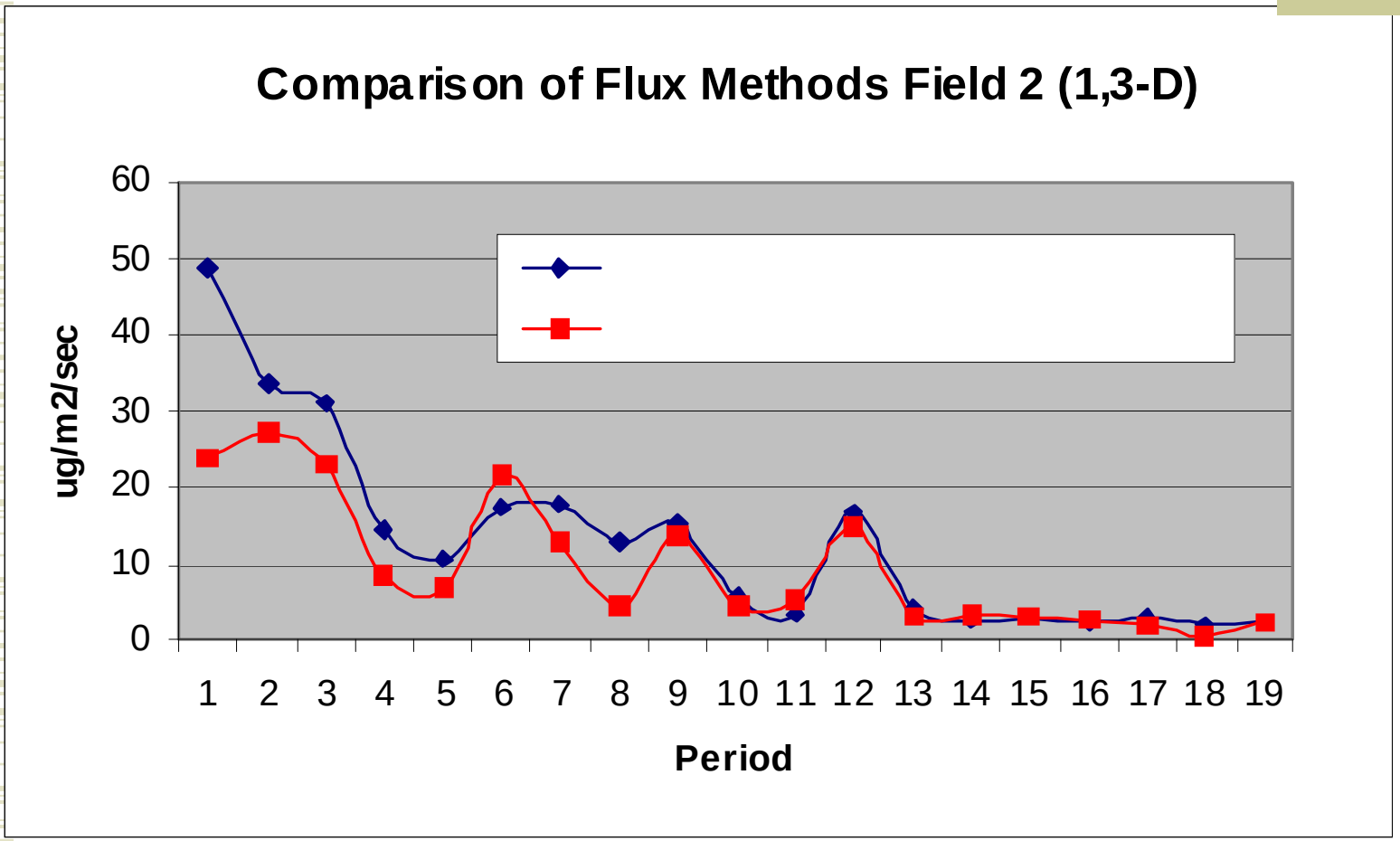
Comparison of Results Between Method

Example: Oxnard, 2006 Chloropicrin Drip

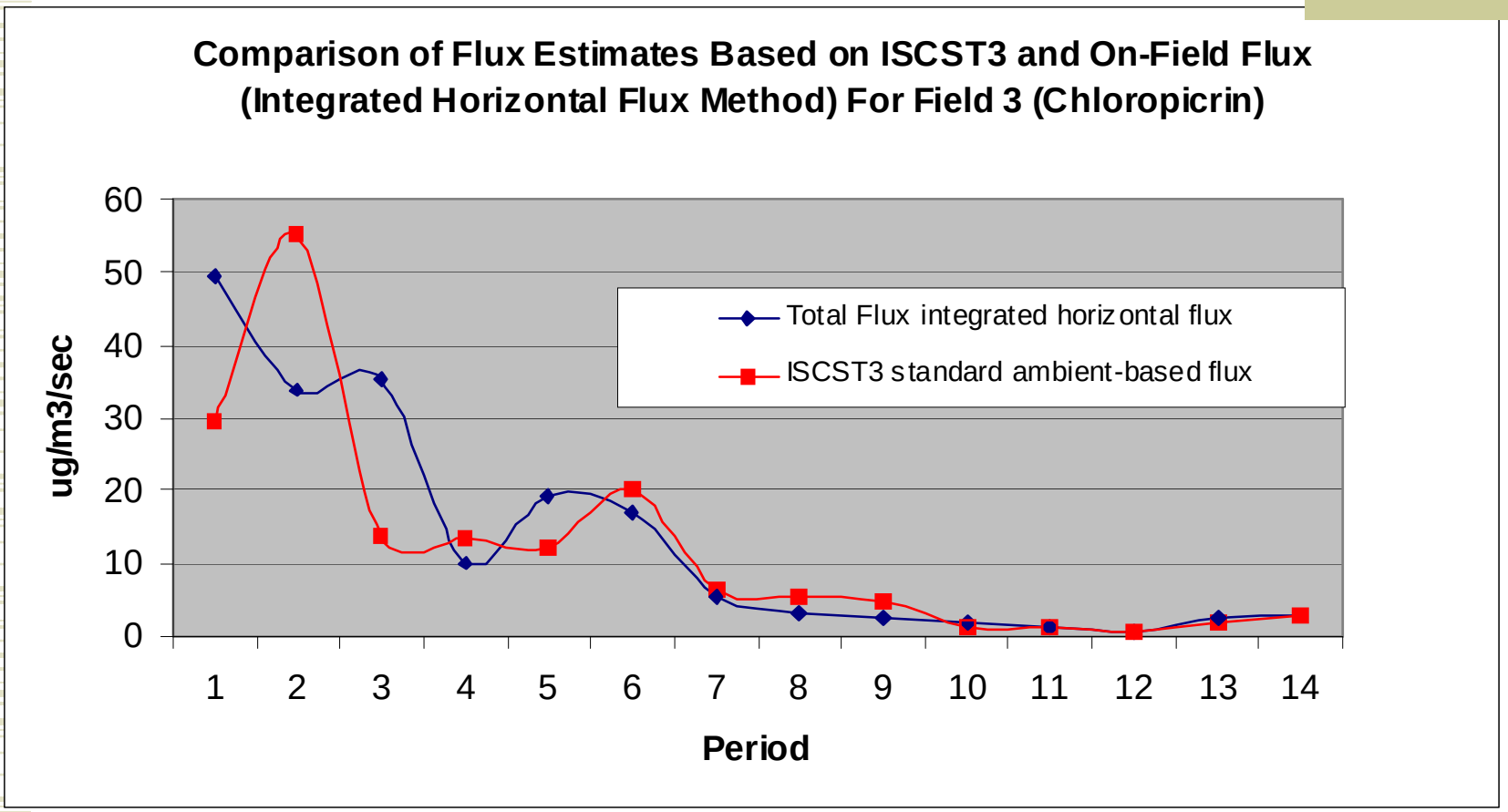


Note divergence first period

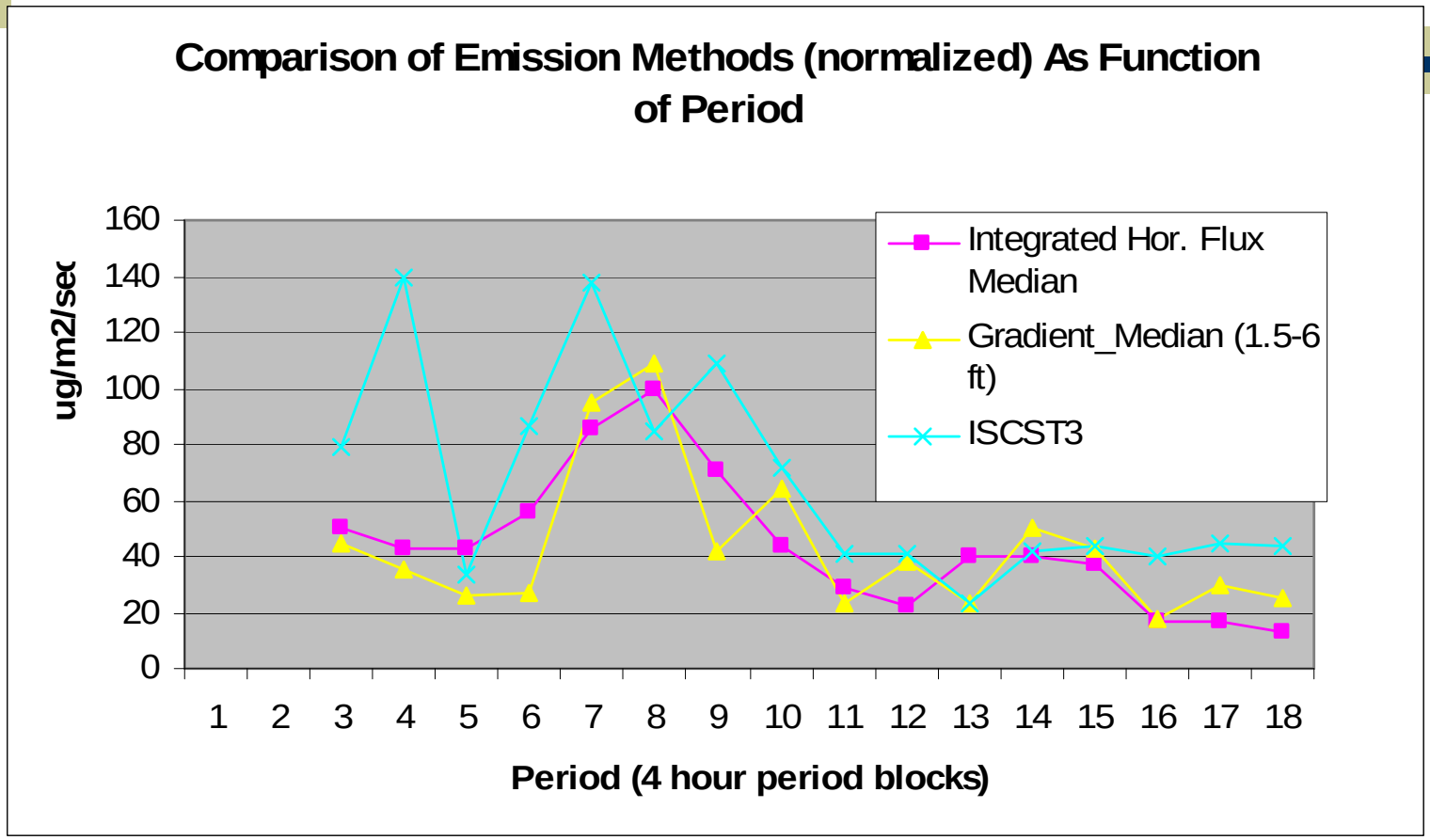
Example: Oxnard, 2006 1,3D Drip



Example: Santa Maria, 2006 Chloropicrin Drip

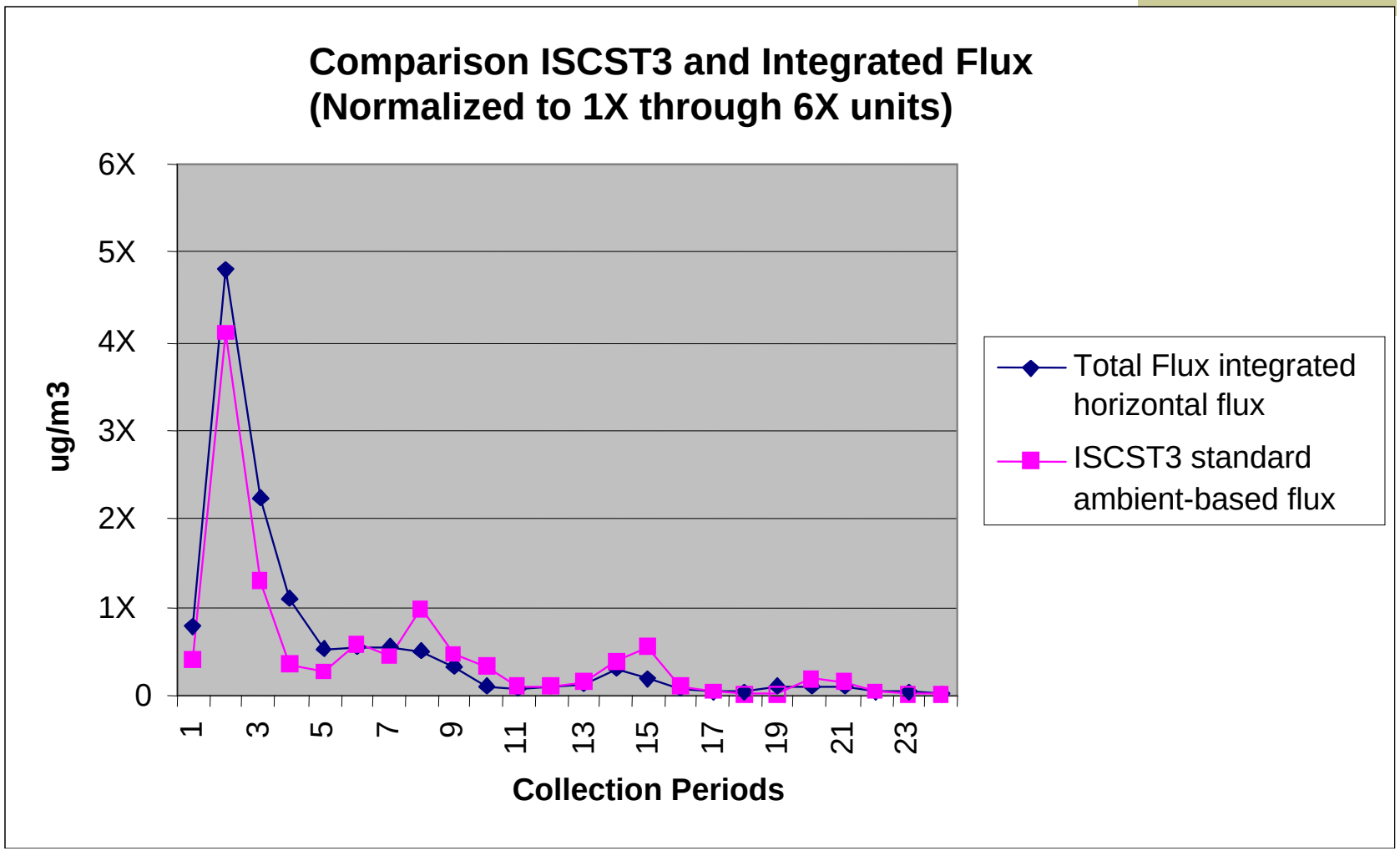


Normalized Example of On-Field Flux Methods in Comparison to Ambient Method (ISCST3) for Shank Injection Broadcast Application

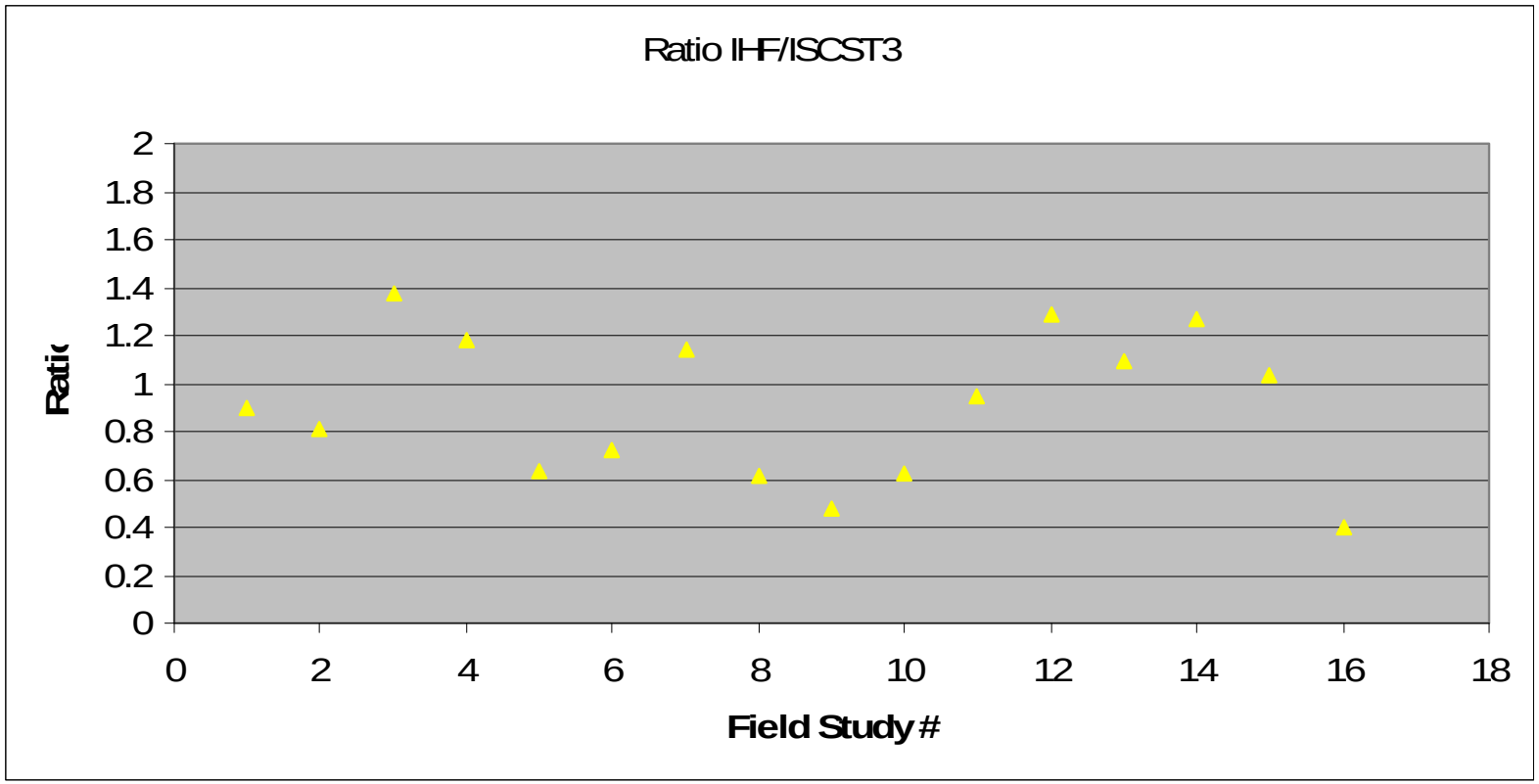


Greatest differences between ISCST3 and on-field flux generally observed during afternoon convective when model limitations appear to increase “calibration” adjustment of fitting procedure

Example of On-Field Flux Methods in Comparison to Ambient Methods for Drip Irrigation Application



Summary: Ratios of Maximum Flux Based on Integrated Horizontal Flux / ISCST3 Method



Convective periods primary reason for ISCST3 method to be higher

Average ratio = 0.9

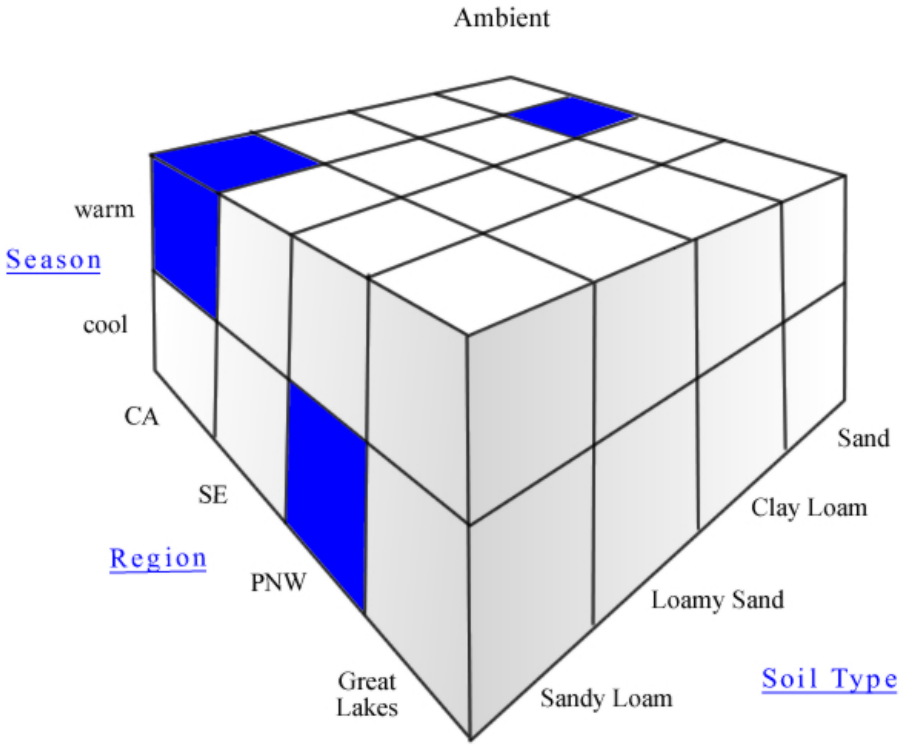
Methods to Optimize On-Field Flux Performance

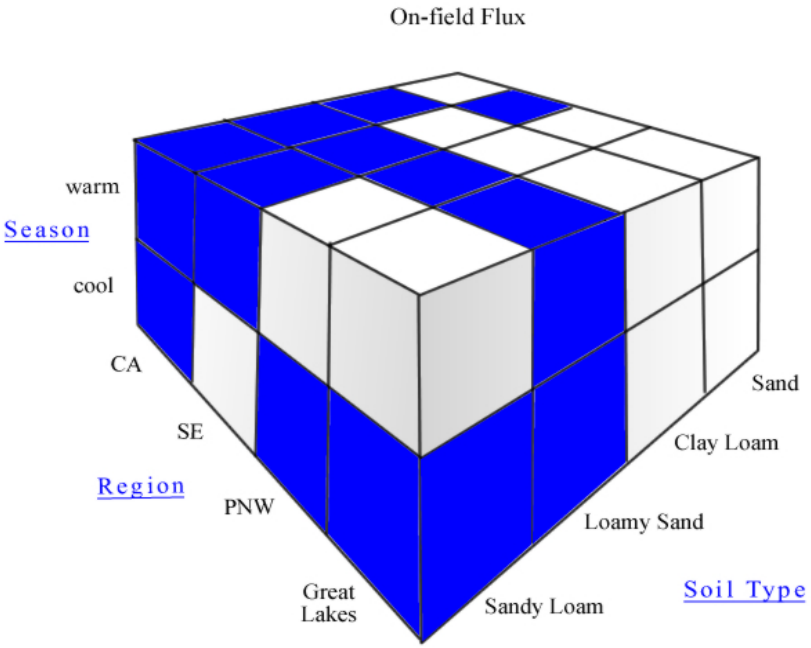
- Integrated horizontal flux method is simple and avoids nocturnal limitations of turbulence scaling theory
- Matching field sizes and profile heights so full plume is captured within profile
- Sonic anemometers eliminate poor wind speed coverage at most critical times (nocturnal, light winds)
- Regression fitting of the profiles enhances extrapolation to full plume

Recommendation

- Transition to on-field profile method - - more efficient use of resources
- More accurate absolute loss estimates
- Nearly as accurate in modeling context (but does not have the benefit of “calibration” of model)
- Cost for on-field flux is 3-4x less than large-scale ambient approach - - for same $$ can increase scope 3-4 x

For Same Resources On-Field Flux Studies Reduce Uncertainty in Spatial and Temporal Variability





Thank You

And thanks to the sponsors of these field programs:

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